Shielding and compton suppression capabilities of the EUROBALL BGO back-catchers*

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The current status of the EUROBALL BGO back-catchers that will be used for the DEGAS project have been investigated. Measurements of the energy spectrum of a ^{137}Cs gamma-ray source with a cluster of 7-fold germanium detectors were performed. Compton-suppression on the germanium energy spectrum was done via offline analysis using the simultaneous measurements of time and energy of a back-catcher unit and the Germanium cluster. Geant4 simulations provide a better understanding of these measurements that will help to improve the design of the DEGAS shielding.

Introduction. The DESPEC Germanium Array Spectrometer DEGAS is a key device on the Decay Spectroscopy (DESPEC) experiment that will be conducted in the future FAIR facility. The purpose of DEGAS is the detection of gamma-rays of very exotic nuclei that will be produced by the Super-FRS and stopped in the AIDA implanter. DEGAS has to have a sensitivity good enough in order to detect efficiently the isomeric gamma-rays of these exotic nuclei and discriminate them from the intense background expected from the secondary radiation produced at the Super-FRS beam-line as well as the environmental background radiation [1]. The BGO crystals of the former EUROBALL back-catchers will be re-configured and placed in the front and side faces of DEGAS such that they will shield the Germanium detectors from all the different background sources allowing as well compton suppression on the Germanium energy spectrum. In this work the shielding and compton suppression capabilities of a back-catcher unit have been tested.

Experimental Setup. A back-catcher unit composed of 6 BGO crystals has been placed in the rear side of a RISING cluster of 7-fold germanium detectors. A ^{137}Cs source has been placed at three different positions as it is indicated in Figure 1. On each case, energy and time spectra for each BGO and Ge crystal have been measured. The trigger of the (MBS) DAQ system is generated by the signal of the first crystal fired in the setup, either Germanium or BGO. Event by event, the time of each crystal's signal relative to a common stop time (provided by the trigger) has been measured. The energy information of the Ge and BGO has been processed with the VME modules V785 ADC and V792 QDC, respectively. Since the rising time of the BGO energy signals ($\sim$ 80 ns) are much faster than the typical ones from the Germanium detectors ($\sim$ 400 ns) they have been delayed 300 ns before they are send to the QDC.

* Work supported by GSI cooperation with T. U. Darmstadt/ HGS-Hire.

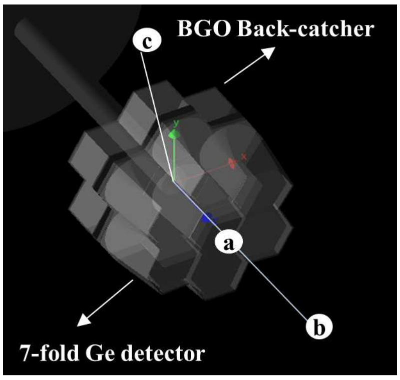

Figure 1: Experimental setup and different source's positions.

Compton suppression performance. When a photon hits a Germanium crystal and is scattered to -at least- one BGO, its total energy cannot be accurately reconstruted by add-backing the energies deposited on the two crystals since the BGO scintillators have very poor intrinsic energy resolution. This event will contribute to the background distribution registered in the germanium energy spectrum and therefore can forbid the observation of peaks with similar energies that correspond to low-probability unknown transitions of nuclei of intereset. Nevertheless, the BGOs can be used to suppress that compton event since the output signals of the Germanium and the particular BGO crystal where the photon has interacted are correlated in time for this event, which means that the time difference between the two signals is constant. When the time difference spectra between an specific pair of detectors is plotted the coincidence events are found at a time position that corresponds to time difference mentioned previously, as it is shown in figure 2.

For the non-central detectors of the 7-fold cluster, compton suppression of the photons scattered

- a. only at the rear BGO crystal,
- b. any BGO crystal,

has been performed. The resulting energy spectra and the comparison with the spectra with no Compton suppression can be seen in Figure 3. P/T ratios of 0.26 and 0.27 were obtained, respectively.

Active shielding capabilities. Figure 4 shows the energy spectra of the events in coincidence between a non-central germanium detector and its rear BGO crystal for the source

DOI:10.15120/GR-2015-1-MU-NUSTAR-GS-07

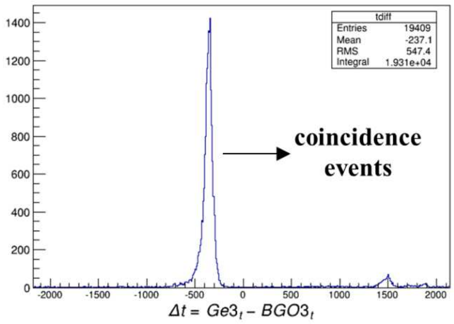

Figure 2: Time difference spectra between a particular combination of BGO-Ge detectors.

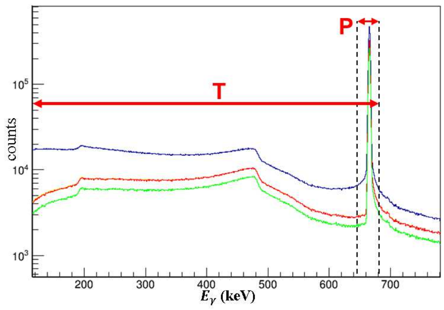

Figure 3: Compton suppression effect on the Germanium energy spectrum testing different anticoincidence conditions.

positions c and b, respectively. When the source was located at the position 'b' the energy deposited in the germanium is in average lower than in BGO. This is explained considering that the photons released from the source first hit the Germanium detector and then are forward scattered to the rear BGO. On the other hand, when the source is located at the non symmetrical position 'c,' the energy registered on the BGO is now in average lower in comparison to the the one registered in the Germanium, which corresponds to the photon forward scattered from the BGO in the direction to the Germanium. These simple observation on the energy distribution of the coincident events allowed to discriminate the different source positions.

References

[1] J. Gerl et. al. "Technical report for the design, construction and commissioning of the DESPEC Germanium Array DEGAS", v12.3, August 2014,

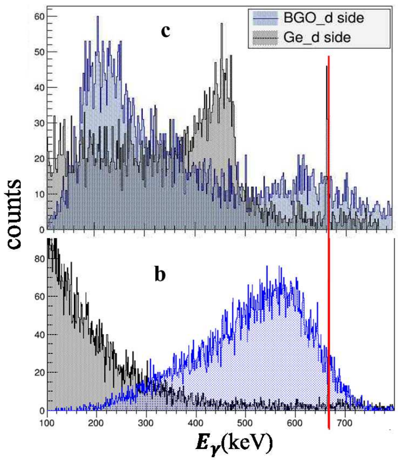

Figure 4: Energy spectra of an specific set of two neighbouring Ge-BGO crystals for events in coincidence when the source placed at positions 'c' and 'b'.

DOI:10.15120/GR-2015-1-MU-NUSTAR-GS-07

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